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Do measures of reactive balance control predict falls in people with stroke returning to the community?

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Abstract

Objective To determine if reactive balance control measures predict falls after discharge from stroke rehabilitation.
Design Prospective cohort study.
Setting Rehabilitation hospital and community.
Participants Independently ambulatory individuals with stroke who were discharged home after inpatient rehabilitation ($n = 95$).
Main outcome measures Balance and gait measures were obtained from a clinical assessment at discharge from inpatient stroke rehabilitation. Measures of reactive balance control were obtained: (1) during quiet standing; (2) when walking; and (3) in response to large postural perturbations. Participants reported falls and activity levels up to 6 months post-discharge. Logistic and Poisson regressions were used to identify measures of reactive balance control that were related to falls post-discharge.
Results Decreased paretic limb contribution to standing balance control [rate ratio 0.8, 95% confidence interval (CI) 0.7 to 1.0; $P = 0.011$], reduced between-limb synchronisation of quiet standing balance control (rate ratio 0.9, 95% CI 0.8 to 0.9; $P < 0.0001$), increased step length variability (rate ratio 1.4, 95% CI 1.2 to 1.7; $P = 0.0011$) and inability to step with the blocked limb (rate ratio 1.2, 95% CI 1.0 to 1.3; $P = 0.013$) were significantly associated with increased fall rates when controlling for age, stroke severity, functional balance and daily walking activity.
Conclusions Impaired reactive balance control in standing and walking predicted increased risk of falls post-discharge from stroke rehabilitation. Specifically, measures that revealed the capacity of both limbs to respond to instability were related to increased risk of falls. These results suggest that post-stroke rehabilitation strategies for falls prevention should train responses to instability, and focus on remediating dyscontrol in the more-affected limb.

Keywords: Accidental falls; Stroke; Rehabilitation; Community; Postural balance

Introduction

Risk of falls post-stroke is high; up to 73% of community-dwelling stroke survivors fall in the 6 months after discharge from hospital [1]. This suggests that those at greatest risk are not identified or prepared for the challenges they will encounter in their everyday living environments [2]. Individuals with stroke often have impaired balance control, which may increase the risk of falls. While several prospective studies of community-dwelling adults with stroke demonstrated a link between functional balance measures and falls [3–5], other studies found no differences in these balance measures between fallers and non-fallers [6,7].

There are several limitations to existing predictors of falls available to clinicians. Clinical measures typically assign numerical values to varying levels of performance on tasks

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that challenge an individual's balance, but are neither able to quantify nor reveal the underlying sources of dyscontrol which make that task challenging. A key factor that ultimately determines whether an individual will fall is the ability to react to a loss of balance [8]. Individuals with stroke have impaired reactive balance control (i.e. the ability to execute appropriate and effective reactions to recover from perturbations to balance) [9–12]. This study aimed to determine if measures of reactive balance control (assessed during quiet standing and walking, and in response to external postural perturbations) predict increased risk of falls for stroke survivors returning to community living following discharge from inpatient rehabilitation. It was hypothesised that impaired reactive balance control in quiet standing and walking, and in response to external postural perturbations would be predictive of increased risk of falls, independent of age, stroke severity, daily walking activity or functional balance measures.

Methods

Study design

This was a prospective cohort study. Participants with stroke were recruited at discharge from inpatient rehabilitation and followed for up to 6 months post-discharge. The study was approved by the Toronto Rehabilitation Institute Research Ethics Board (Ref. TRI REB No.10-043). Participants provided written informed consent prior to participation.

Participants

Individuals with stroke attending inpatient rehabilitation at the Toronto Rehabilitation Institute were eligible for the study if they were: (1) assessed in a specialised balance clinic at discharge; (2) discharged home; and (3) able to ambulate independently (i.e. without assistance/supervision of another person, with or without a gait aid) at the time of discharge. The clinic assessment was completed as part of routine practice by all individuals who had sufficient physical, communication and cognitive function to complete the assessment (as determined by the primary treating physiotherapist); therefore, no further exclusion criteria were applied.

Predictor variables

Measures of reactive balance control were obtained from the clinic assessment. Variables focused on three domains: (1) quiet standing, (2) walking and (3) perturbation-evoked reactive stepping. Additional data were obtained from participants' hospital charts, including age, sex, type of stroke, time post-stroke, affected hemisphere, pre-morbid falls history, National Institutes of Health Stroke Scale [13] scores, and Berg Balance Scale [14] scores. The National Institute of Health Stroke Scale is an 11-item scale that provides a gross measure of the effects and severity of stroke, with higher scores indicating more severe strokes. Items assess cognition (level of consciousness, orientation and ability to follow commands), gaze, visual fields, facial palsy, gross motor function in the arm and leg, ataxia, sensation, language, speech, and extinction and inattention. The Berg Balance Scale is a 14-item observational rating scale that provides a measure of functional anticipatory balance control (rather than reactive balance control). For participants with bilateral stroke, the more-affected side was identified.

Quiet standing

Participants stood in a standardised foot position [15] with one foot on each of two force plates for 30 seconds, and were asked to stand as still as possible with their eyes open. Forces and moments were recorded from the force plates at 256 Hz and filtered using a 10-Hz low-pass zero phase lag Butterworth filter prior to processing. The antero-posterior and medio-lateral centres of pressure (COP) were calculated for each force plate separately and for both feet combined. The root mean square (RMS) of total antero-posterior and medio-lateral COP were calculated to provide a measure of overall COP variability. The contribution of the paretic limb to balance control was calculated by dividing the RMS of antero-posterior COP under the more-affected limb by the sum of the RMS of antero-posterior COP under each limb [16,17]; a value of 0.5 indicates that both limbs contribute equally to balance control, <0.5 indicates that the less-affected limb contributes more to balance control, and >0.5 indicates that the more-affected limb contributes more to balance control. Between-limb synchronisation of antero-posterior COP was calculated by determining the correlation coefficient between the left and right antero-posterior COP [18,19]. Antero-posterior COP was used for the contribution and synchronisation measures as individual-limb medio-lateral COP is less meaningful for overall bipedal balance control [20].

Walking

Participants walked across a 4-m-long pressure mat at their usual pace without a walking aid (whenever possible). Participants walked across the mat three to five times such that at least 18 footfalls were recorded. Step length, step width and step time were calculated for each step. The standard deviations of step length, width and time were calculated for each limb separately; variability was calculated as the average of the standard deviations for the left and right limbs. Overall walking speed was also calculated.

Reactive stepping

A lean-and-release system was used to study reactive stepping [9,10,12]. Participants stood in a standardised foot position [15], and wore a belt around their trunks attached to a beam via a cable. Participants leaned forward such that approximately 10% of body weight was supported by the